

PACIFICON 2017

ARRL Pacific Division Ham Radio Convention
Produced by the Mount Diablo Amateur Radio Club

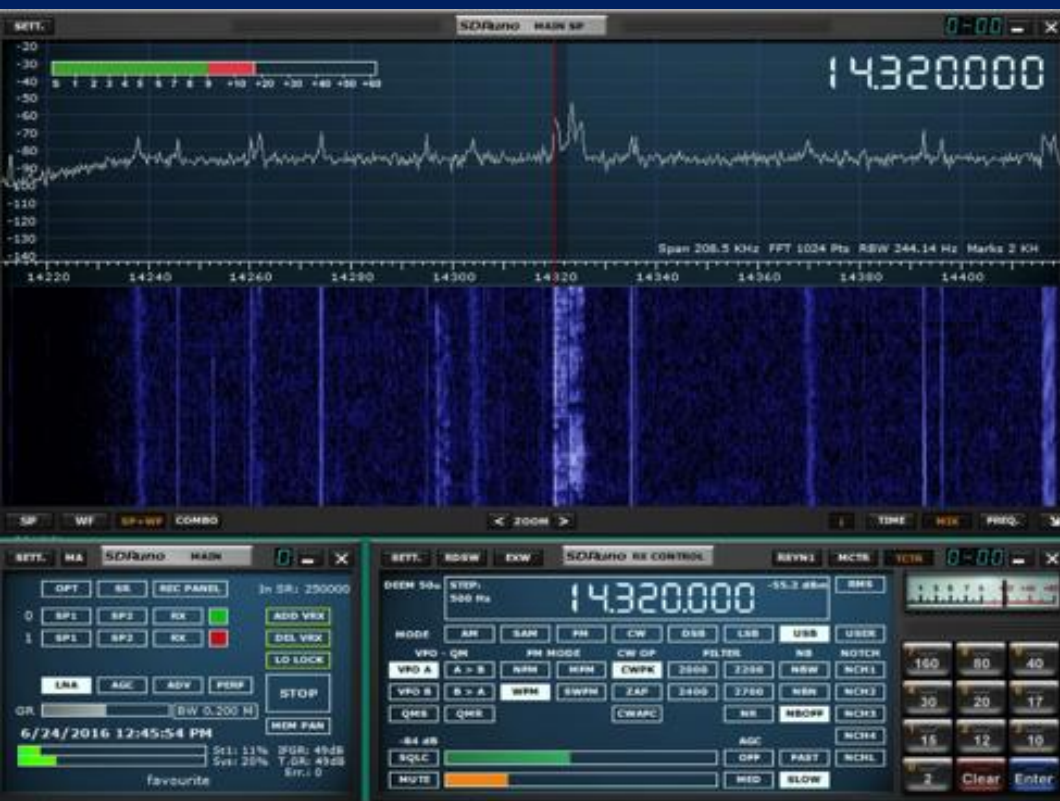


An Introduction to Software-Defined Radio

Steve Brightman

SDRplay Ltd

www.sdrplay.com



Contents

- What is an SDR?
- Why do I want one?
- Review of SDR solutions
- SDR software
- Applications
- Panadapters
- Where to buy an RSP and find further information

What is an SDR?

A radio communication system where components that have been traditionally implemented in hardware...

(e.g. mixers, filters, amplifiers, modulators/demodulators, detectors, etc.)

...are implemented by software on a PC or embedded system.

What comprises an SDR?



1. Hardware to amplify, filter and digitize radio signals
1. Software to provide advanced filtering, demodulation/decoding and control functions

Why do I want one?



- True general coverage
- Work one frequency and still monitor the band
- Panadapter (regular vision vs rifle scope!)
- Filters! (brick-wall envelopes... software updatability)
- Audio and IF Digital Signal Processing (DSP)
- Harness the power of your existing PC
- Multiple VFOs
- Record large bandwidths
- Record/playback of audio
- Special purpose receiver:
 - WX satellites, aircraft monitoring, digital stations, TV, Ionosondes! etc etc
- **Can you ever have too many receivers?** ☐

Review of SDR receivers:

The Catalyst for Hams: RTL Dongle

- see <http://www.rtl-sdr.com>
- Designed for mobile TV reception outside the US (esp. Europe)
- Italian ham realized that the hardware was broadband--very broadband--so he wrote a new firmware that can be used with the TV dongle and a PC to yield Software Defined Radio Reception
- Cheap! Began around \$100 but now down to \$10 or less for some models



Review of SDR receivers

– what to consider:



- **Frequency Range:** The range of frequencies the SDR can tune to.
- **ADC Resolution:** Higher is better. More resolution means more dynamic range, less signal imaging, a lower noise floor, more sensitivity when strong signals are present and better ability to discern weak signals. Some SDR's give their resolution in ENOB which stands for effective number of bits.
- **Instantaneous Bandwidth:** The size of the real time RF chunk available.
- **RX/TX:** Can the radio receive and/or transmit.
- **Preselectors:** Analogue filters on the front end to help reduce out of band interference and imaging.
- **Price**

Review of SDR receivers

– The 8-bit dongle



R820T RTL2832U a.k.a RTL-SDR

Cost: \$10 – 22 USD

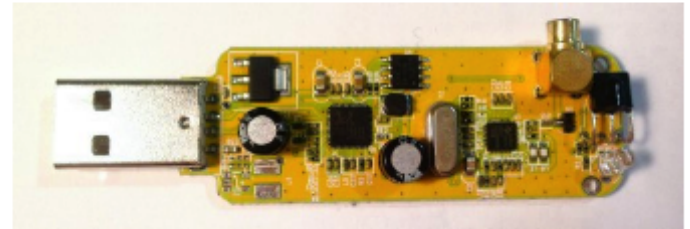
Frequency Range: approx. 24 MHz – 1766 MHz

ADC Resolution: 8 Bits

Max Bandwidth: 3.2 MHz / 2.4 or 2.8 MHz max stable.

TX/RX: RX Only

Preselectors: None



The RTL-SDR is still the best 'bang for your buck' software defined radio out there. While it was never designed to be used as a general purpose SDR in the first place, its performance is still surprisingly good. If you're on a budget or are just starting out with SDR or radio this is the one to get. ([Link](#))

source: rtl-sdr.com

Cheap and cheerful!

Review of SDR receivers

High-end example - The Perseus:



Perseus SDR

Cost: \$1,100 USD

Frequency Range: 10 kHz – 40 MHz

ADC Resolution: 14 Bits

Max Bandwidth: 1.6 MHz

TX/RX: RX Only

Preselectors: Yes 10 switched

Many owners of this SDR claim that it is one of the lowest noise SDRs available and that it is great for DXing. ([Link](#))



source: rtl-sdr.com

Expensive and capable!

Review of SDR receivers



Comparisons with other common Wideband Commercial Software Defined Radios

SDR	Tune Low (MHz)	Tune Max (MHz)	RX Bandwidth (MHz)	ADC Resolution (Bits)	Transmit? (Yes/No)	Price (\$USD)
RTL-SDR (R820T)	24	1766	3.2	8	No	~20
Funcube Pro+	0.15 410	260 2050	0.192	16	No	~200
Airspy	24	1800	10	12	No	199
SDRplay	0.001	2000	10	12	No	120 - 192
HackRF	30	6000	20	8	Yes	299
BladeRF	300	3800	40	12	Yes	400 & 650
USRP 1	DC	6000	64	12	Yes	700

For those who just want to receive a wide range of signals, we recommend the Airspy or SDRPlay as an upgrade to the RTL-SDR. If you are mainly interested in narrowband signals the Funcube Dongle Pro+ may be worth considering.

The RSP Family



RSP1



RSP2



RSP2pro





KEY FEATURES	RSP1	RSP2	RSP2pro
Continuous coverage from 1 kHz to 2 GHz (RSP1 from 10 kHz)	✓	✓	✓
Up to 10 MHz visible bandwidth	✓	✓	✓
Powers over the USB cable with a simple type B socket	✓	✓	✓
High Performance ADC silicon technology (not another 8 bit dongle!)	✓	✓	✓
8 built in front-end pre-selection filters	✓		
10 high-selectivity, built in front-end preselection filters			✓
Software selectable (On/Off) Low Noise Preamplifier	✓		
Software selectable multi-level Low Noise Preamplifier		✓	✓
SDRuno—World Class Windows SDR software	✓	✓	✓
Open API for new apps development	✓	✓	✓
Single SMA antenna socket	✓		
2 x SMA Software Selectable Antenna Inputs		✓	✓
1 x High Impedance Input for long wire antennas		✓	✓
Software selectable MW /FM notch filters		✓	✓
Highly stable 0.5PPM TCXO trimmable to 0.01PPM		✓	✓
24MHz Reference clock input / output connections		✓	✓
4.7V Bias-T (Port B only)		✓	✓
Robust and strong plastic case	✓	✓	
RF shielding layer inside case		✓	
Rugged metal case			✓

Which RSP for me?

All RSPs from SDRplay are Software Defined Radios which can turn a PC into a general coverage receiver or spectrum analyser spanning VLF (1kHz) through to Microwaves (2GHz).

With dual 12 bit A/D front end converters and very sharp 5th order Chebyshev filters, the RSP allows processing of a 10MHz slice of radio spectrum all in one go.

- RSP1 has single input, low-price. Great choice for building a panadapter!
- RSP2 adds:
 - Multiple inputs (for antenna switching)
 - AM/FM Broadcast Band Filters
 - Bias-T available for powered antennae (5V)
 - TCXO (for greater accuracy)
 - Reference Oscillator In/Out (for even greater accuracy or synchronisation)
- RSP2pro is the same specification as RSP2 but in a rugged metal case

Ham Radio Science says...



The screenshot shows the Ham Radio Science website. At the top is the site's logo and navigation links: HOME, RESOURCES, DISCLAIMER, FORUM. Below this is a secondary navigation bar with links: ANNOUNCEMENTS, FEATURED, INTERFACES, OPERATING, OPINIONS, PROJECTS, REVIEWS, SDR RADIO. The main content area features an article titled "SDRPlay RSP2 Review" dated November 22, 2016, with "Featured" and "2 Comments" tags. To the left of the article is a sidebar with an "UPDATES VIA EMAIL" section, a "HAM IT UP CASE" section featuring an Amazon link for a "NooElec NESDR" device, and a "Shop now" button. The article text begins with an "Introduction" and discusses the SDRPlay RSP2's performance and features.

Ham Radio Science

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\$19.95 Prime

Shop now

NOOELEC NESDR

SDRPlay RSP2 Review

November 22, 2016 | [Featured](#) | [2 Comments](#)

Introduction

If you have read our past articles on the SDRPlay RSP, you probably noticed that it has been a highly regarded SDR receiver here at HRS. It was named as the best SDR radio available in its price category. The SDRPlay RSP is even good enough to hold its own against far more expensive SDR products. Not to mention that it comes with excellent support from SDRPlay team. Over the past year, the SDRPlay got even better when SDRPlay acquired the excellent Studio One SDR software and adapted for use with the SDRPlay RSP. The new version of Studio One for the SDRPlay was renamed to SDRRuno. The addition of SDRRuno to the SDRPlay makes the RSP even a better value by adding a very powerful SDR program with a very attractive and professional user interface. Unlike some SDR programs that look pretty dated in comparison. The SDRPlay team continues to add new features and improvements to SDRRuno on a very frequent basis. Not to mention that the price of the SDRPlay RSP has been lowered to \$129 and is easily available in the US from [Ham Radio Outlet](#). With the SDRPlay RSP's low price, continuous coverage from 10 kHz to 2 GHz, 10 MHz of spectrum, great software, and excellent technical support how could it be any better. Well, it just did. The SDRPlay Team not content to rest on it's laurels has listened to it users and has added some significant new features and has improved some of the original RSP's specs. The new product is called the

Conclusion

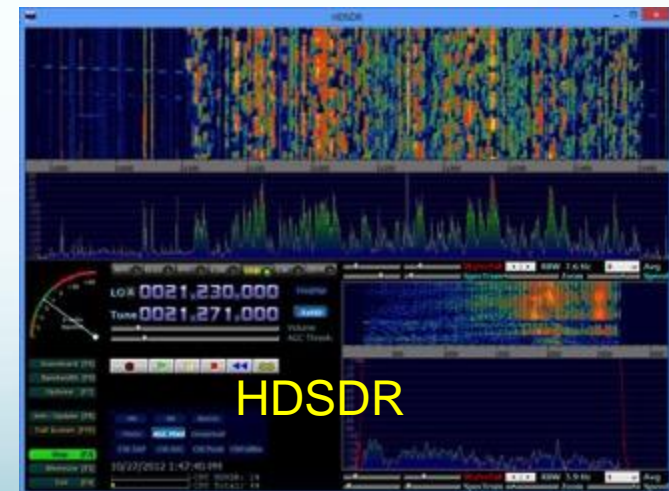
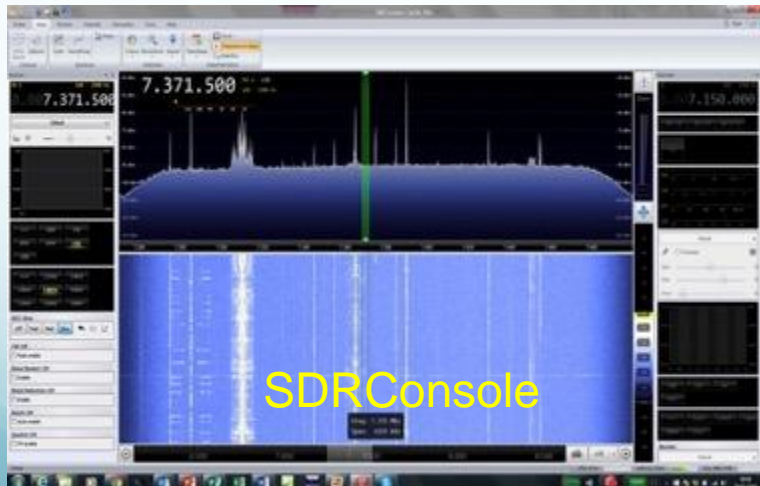
It was hard to believe that the very competent RSP1 could be made any better of a value, but the SDRPlay Team were able to pull it off. The RSP2 really ups the ante against it's competition with features it offers.



Software

Software

- SDRuno – World class Windows software (included)
- Multi-platform support for Windows, Mac, Linux, Android, Raspberry Pi 2/3
- Compatible with existing open source radio software
- ExtIO based plugin ensures compatibility with growing number of packages
- Access to free Mirics Radio & TV decode software (Europe)
- Software upgradeable for future standards
- API provided to allow demodulator or application development
- 3rd Party **free** software including SDR-Console, HDSDR and CubicSDR



SDRuno



SDRuno – Key Features

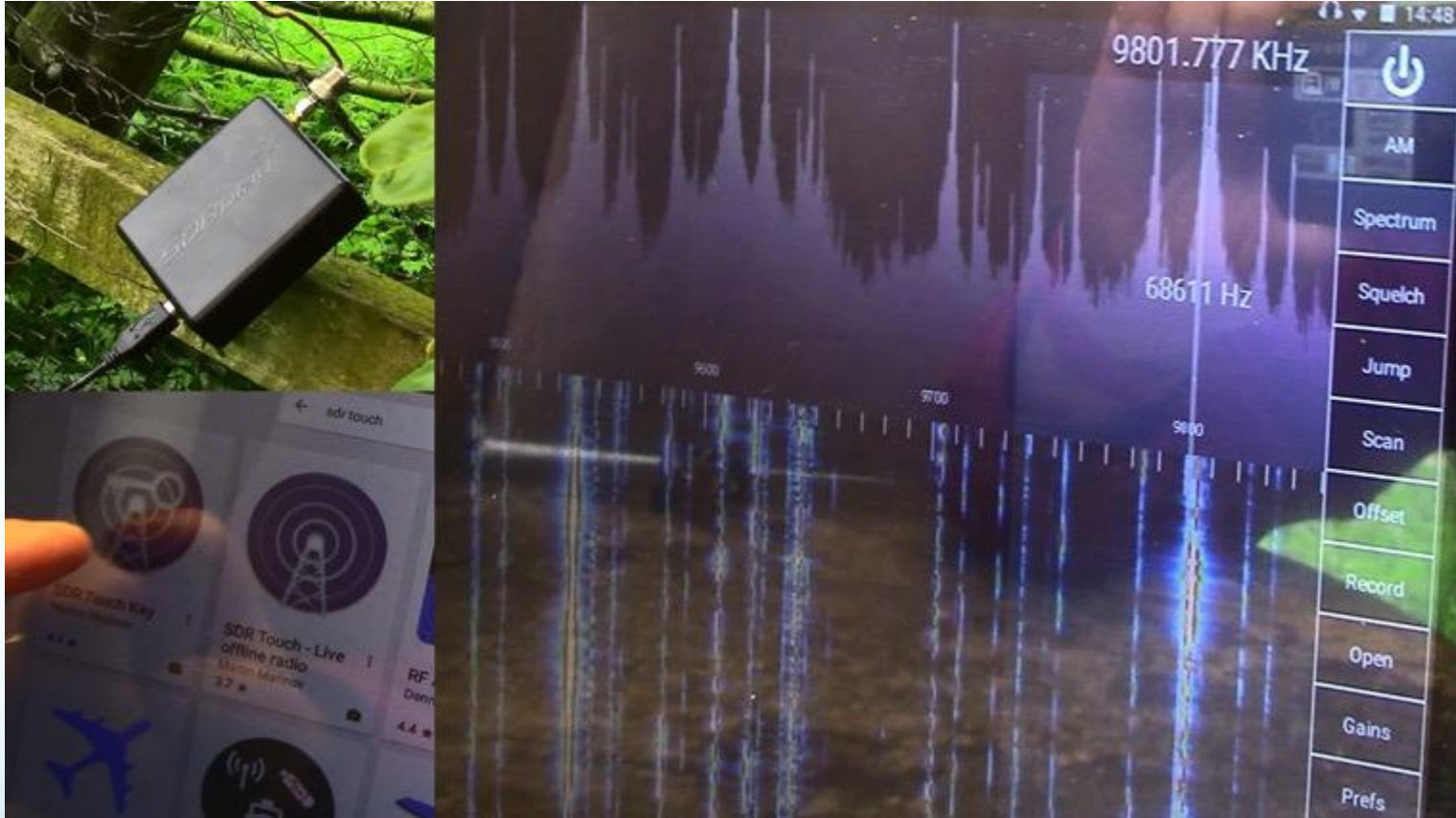


- Up to 10MHz visible bandwidth
- Up to 16 VRX (Virtual Receivers)
- Main and Auxiliary Spectrum Windows for each VRX
- Multiple Memory Banks
- Programmable Notch filters
- Support for 3rd party software via Virtual Audio Connections
- Support for OmniRig (Panadapter) and T-mate Controller
- Calibrated Power Meter
- *Plus so much more!*

SDRuno – Key Features



Android Phones and Tablets



- SDR Touch (RSP1 only) and SDRplay Driver, available from the Android Market
- The Android device must support USB On-The-Go

Summary - Platforms + software examples supported by RSP



- Windows (XP, 7, 8, 10) for SDR-Console, HDSDR, Studio1 etc.)
- Mac (CubicSDR)
- Linux (CubicSDR, gr-osmosdr)
- Android (SDR Touch & SDRplay plug-in)
- Raspberry Pi 2/3 (growing Github resources)
- ARM64 (SoapySDR and CubicSDR)

Applications

- Today's SDRs offer the opportunity to go beyond traditional Ham communications
- The following slides illustrate some real-world examples from our customers – all using the RSP!
- Some of them require the use of add-on software, most of which is available free!

Applications: An RF Power meter



Using the SDRplay RSP2 for versatile RF Power measurement

1% accuracy!



www.SDRplay.com



Add-on Software

- Satellite working



WD9EWK VHF crossed dipole
& Tablet + RSP for telemetry

NOAA Weather satellite - Wxtoimg



Credit: Jeff Broughton, WB8RJY

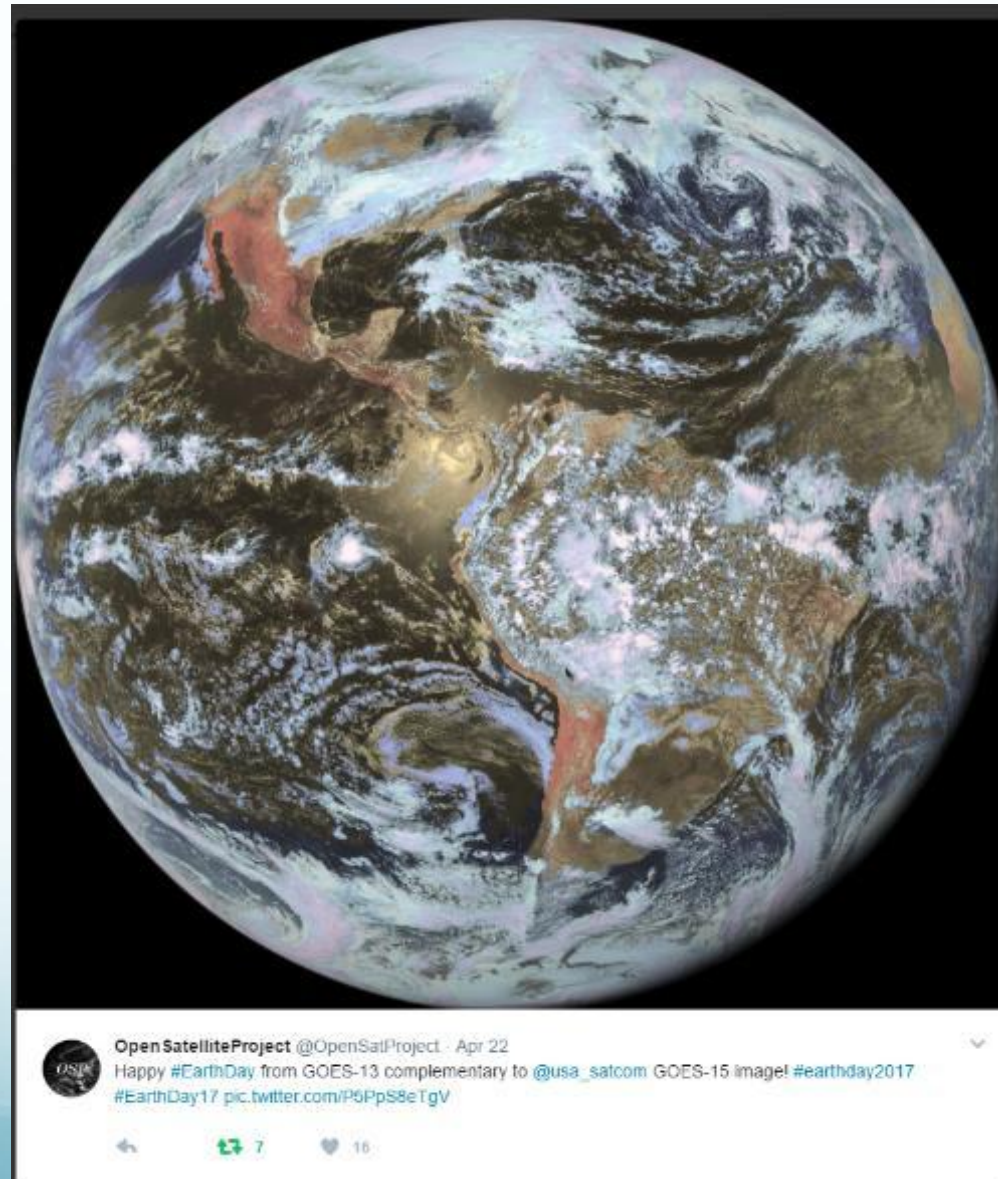
User pictures from the facebook group:
www.facebook.com/groups/sdrplay/

Wxtoimg:
<http://www.wxtoimg.com>



Credit: Sefi Merkel

Hi Resolution satellite images (1.7GHz) RSP2



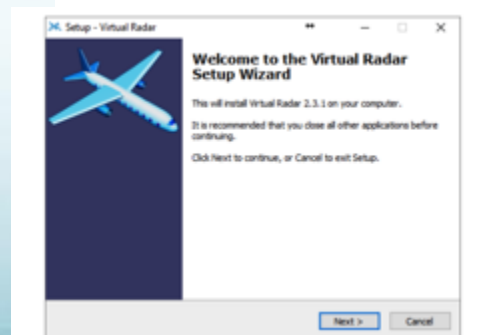
ADS-B using Dump1090



Detect aircraft in your vicinity – SDRplay provides s/w and set-up wizards to drive ‘Virtual radar’ mapping software

The screenshot shows the SDRplay website with the following content:

- Navigation bar: Home, Start Here, Platforms, Community, Purchase, Reviews, Blog, FAQ, About Us, Contact. Social media icons for Facebook, Twitter, and YouTube.
- Section: **Windows** (with a star icon) and "Windows related information".
- Text: "New customers should use the "Start Here" guide for software installations."
- Section: **Generic Documentation**
 - RSP Single Page Datasheet (English)
 - RSP Single Page Datasheet (French)
 - Detailed Technical Specification
 - API Specification
 - AGC Technical Note
 - RSP Conceptual Block Diagram
 - RSP Schematics
- Information box (light blue background):
 - Current API Installer: 1.8.1 (Release date: 11th January 2016)
 - Current EXTIO Plugin: 3.8.3 (Release date: 23rd February 2016)
 - Current SDR# Plugin: 2.2 (Release date: 12th October 2015)
- Information box (light blue background):
 - ADS-B (dump1090): 1.13 (Release date: 1st May 2016) User Guide



ADS-B decoding example using Dump1090 and VRS



Virtual Radar (16)
127.0.0.1/virtualRadar/desktop.html#

N146AA
American Airlines
United States
Airbus A321 231SL
Altitude: 5725 ft Vertical Speed: -192 ft/m Speed: 239.0 kts Heading: 313.0° Distance: 3.90 nmi Squawk: 3412 Engines: Twin jet Species: Landplane
Wake Turbulence: Medium
Route: KDFW Dallas Fort Worth, Dallas-Fort Worth, United States KSEA Seattle Tacoma, United States
www.airport-data.com : www.airliners.net : www.airframes.org
Show on map :: Disable auto-select :: Submit route correction

A0B8FB
AAL1609
Civil
A321

Tracking 16 aircraft

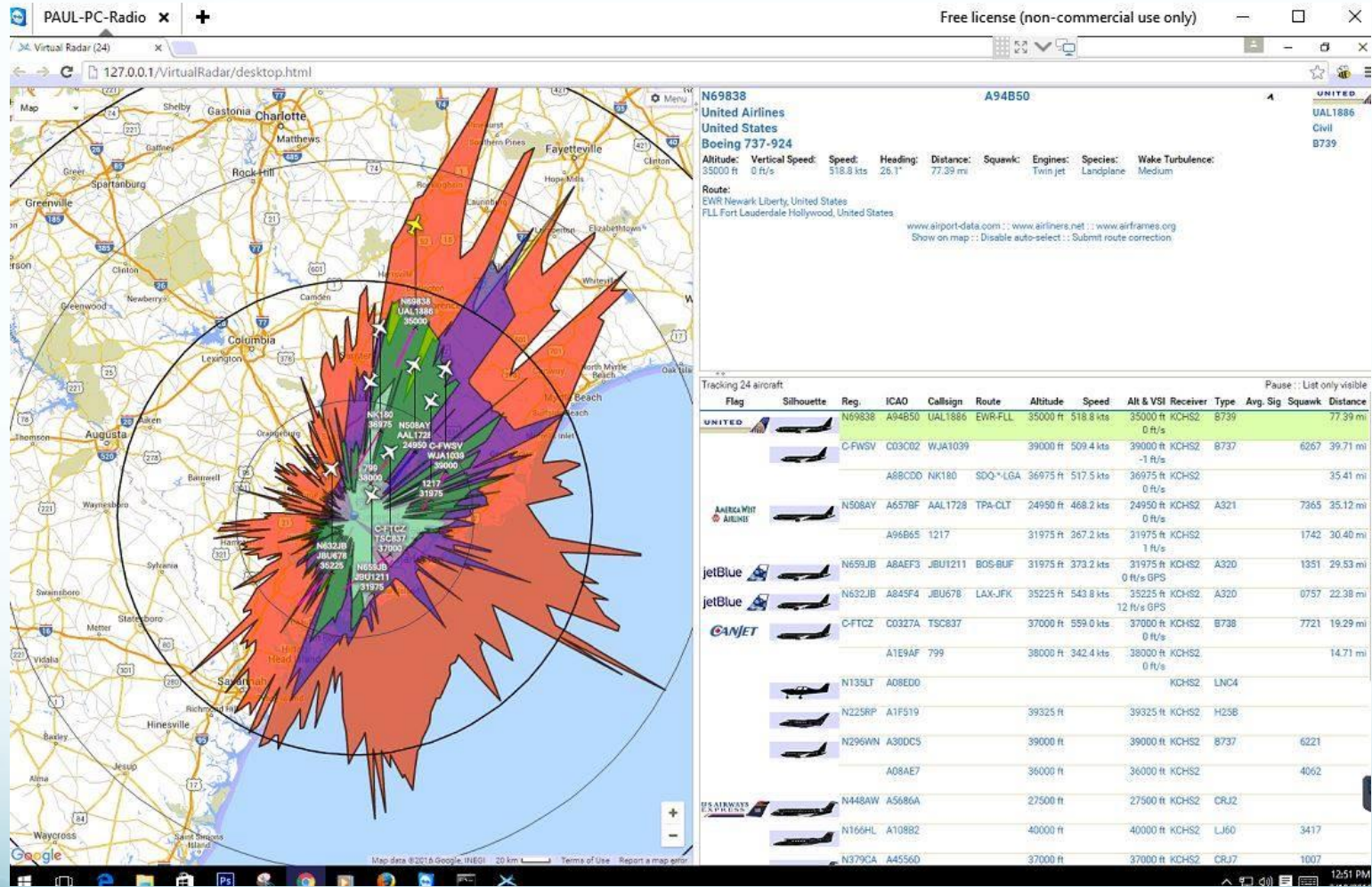
Silhouette	Flag	Reg.	ICAO	Callsign	Route	Altitude	Speed
		N440AS	A54AAE			10050 ft	294.0 kts
		N837DN	AB72B3			14825 ft	333.0 kts
		N536AS	A6C6C8	ASA448		18325 ft	379.0 kts
		N508AS	A657B9			12125 ft	
		N6130X	A7FB57			31450 ft	
		N224AG	A1EFE4			19975 ft	
		N483AS	A5F3CF	ASA787		11775 ft	286.0 kts
		N781QS	AA95AC	EJA781		3750 ft	185.0 kts
		N799AS	AAD985			25400 ft	
		N6030X	A7D3D8			4850 ft	
		N474AS	A5D007	ASA894	PHKO-KSJC	9925 ft	278.0 kts
		N146AA	A0B8FB	AAL1609	KDFW-KSEA	5725 ft	239.0 kts
		N856DN	AB8DFA	DAL2210	KDFW*-KROC	7575 ft	251.0 kts
		N588AS	A793D1			6550 ft	

Administrator: SDRplay dump1090 V1.11.1903.16

Hex	Mode	Squk	Flight	Alt	Spd	Hdg	Lat	Long	Sig	Msgs	Ti
406134	S	5741		38000	436	316			21	10	1
406004	S								18	1	23
40A64E	S	6763		15325	304	025	51.591	-0.229	41	36	4
484B00	S	7626		5325	254	020	51.601	-0.183	31	48	5
601839	S		TUA427	7450	270	269			26	20	2
400E59	S	5736		34000			51.911	-0.257	26	35	22
48B144	S	3232	THY33	32000	489	269	51.585	-0.077	30	354	0
406871	S	5005		1200					36	25	8
400F28	S	0043		1600					69	136	0

Credit: Max Santos, AC5PY

Another example: Dump1090 and VRS

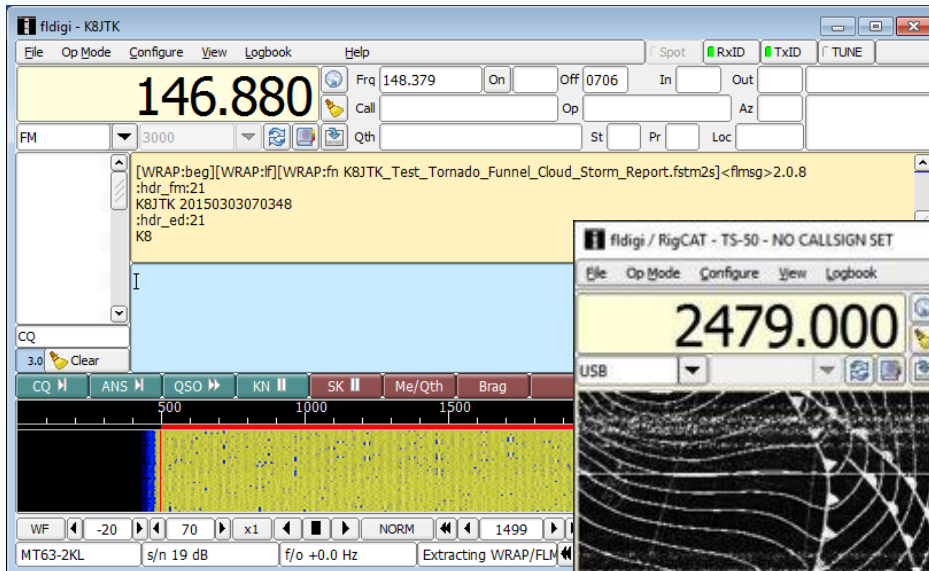


Virtual Radar Server: <http://www.virtualradarserver.co.uk>

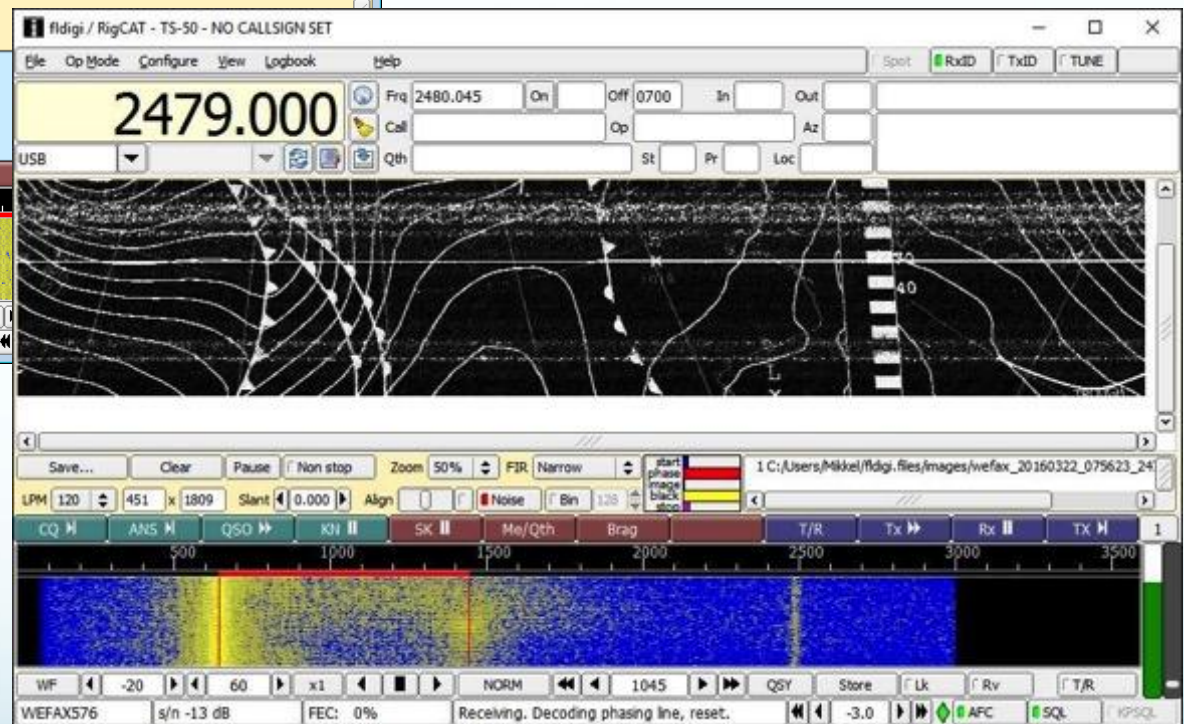
Credit: Paul Jones, NN4F

FLdigi

NBEMS (Narrow Band Emergency Messaging System)



...and WEFAX Decoding

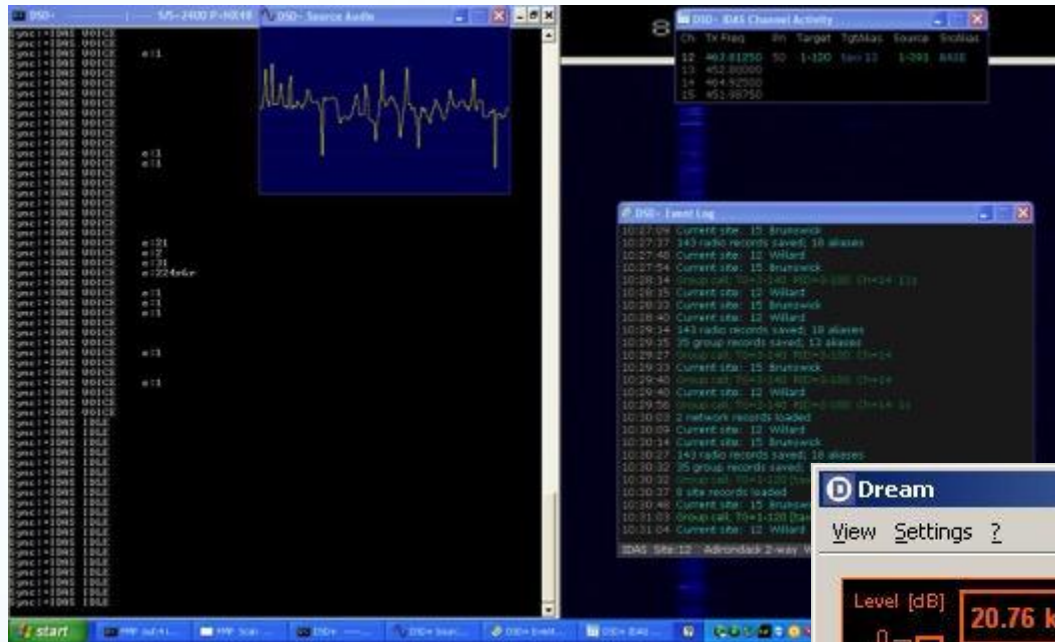


Credit: Jeff Kopcak, k8jtk

FLdigi: <http://www.w1hkj.com>

Credit: Erik Mikkil Wied

Digital Speech Decoding with DSD+



DRM with Dream

Credit: David Stark, NF2G

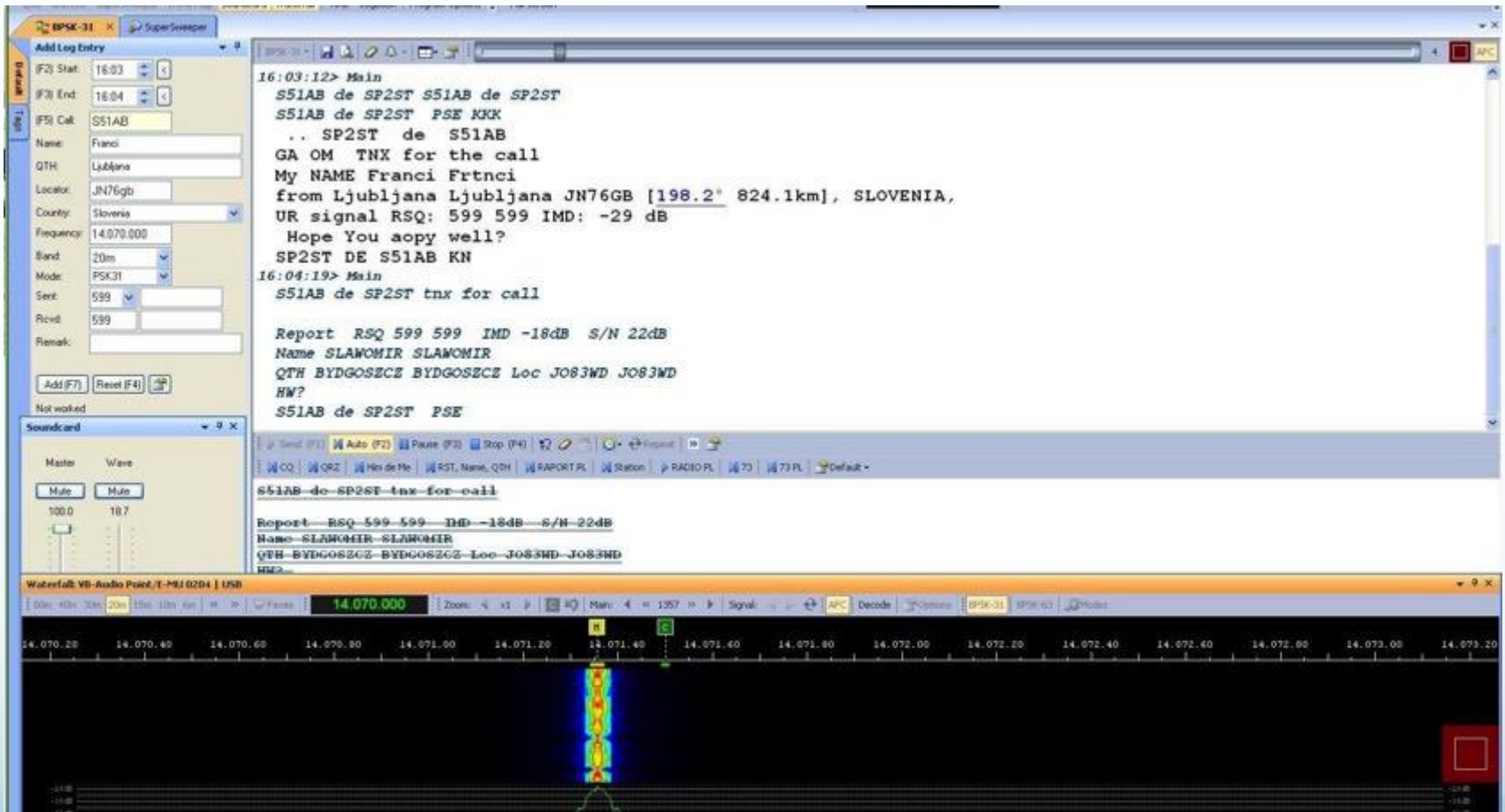
DSD+:

<http://www.dsdplus.com>

Dream: <https://sourceforge.net/projects/drm/>



Digital Master 780 (Ham Radio Deluxe)



Ham Radio Deluxe / DM780: <http://ham-radio-deluxe.com>

Credit: Sławomir Teclaw, SP2ST

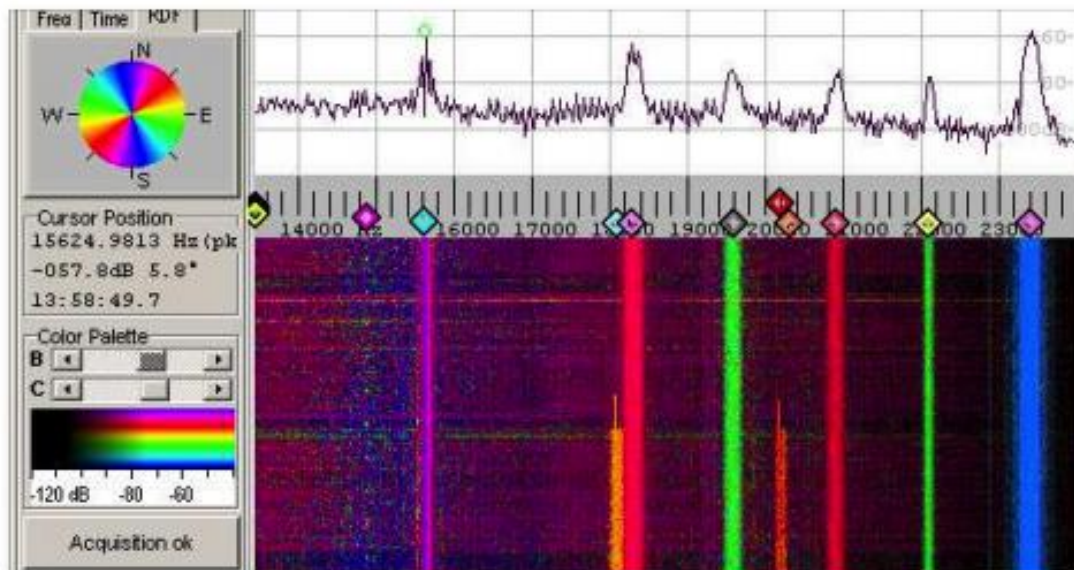
Other EXTIO-based software:

- Spectrum Analyzer example



"I took the SDRplay HDSDR ExtIO DLL file and loaded it into Spectrum Lab, and it works 😊 - needs more investigating, but it sure works.... "

The Spectrum Analyzer software can be downloaded from
<http://www.qsl.net/dl4yhf/spectra1.html>



DL4YHF's Audio Spectrum Analyser

Spectrum Laboratory for Soundcard with Waterfall and FFT.

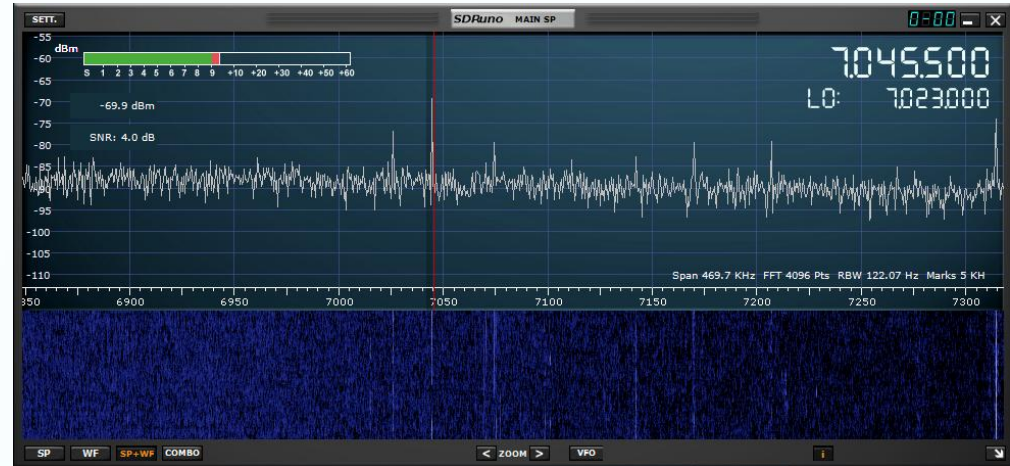
QSL.NET

Panadapters

What is a Panadapter?



- Panadapter is short for Panoramic Adapter. The simple answer is that it allows us to see a panoramic display of the band our radio is tuned to. We can see every signal.
- The advent of affordable SDR hardware such as the RSP has allowed implementations with much greater bandwidth, and hence much more usefulness.
- Combined with readily available, and capable, SDR software Panadapters are now an affordable and easy to implement reality!
- Some transceiver manufacturers now offer built-in Panadapter capabilities, or add-on hardware. However, an RSP still offers you the chance of a larger, more legible display, and is still the cheapest add-on option.



RSP Panadapter Advantages

1. Ability to monitor the entire band at once and identify newly active frequencies.
2. Monitor multiple bands at once – work one band and keep an eye on another!
3. Cheaper than the manufacturer's panadapter add-on.
4. Offers a larger display than built-in spectrum scopes.
5. User-customizable appearance and size.
6. Add panadapter capabilities to *any* rig, although full synchronization requires a CAT-equipped receiver.

Panadapters

- Hardware Requirements

- An RSP — to acquire signals across the frequencies of interest.
- A TRX (or main RX)- preferably with either RxOut or IF Out capabilities, and CAT (Computer Aided Transceiver) capability to allow interaction with the SDR software.
- A PC — to run the SDR software and allow control signals to pass back and forth between the SDR software and the transceiver.
- **Protection** — for the RSP during transmit. This may be already built-in to the transceiver (if using RF- or IF-out) or by use of an external T/R switch

* Please see our website for an overview of panadapters, including these slides.

Panadapters

- Antenna Considerations



- The RSP can share the same antenna as your transceiver, or in some situations you may prefer to use an entirely separate antenna.
- If a separate antenna is used care must be taken with the physical layout to ensure that near-field effects do not overload the RSP1 when you are transmitting from the transceiver.
 - Article discussion of near-field effects: http://www.w8ji.com/antenna_coupling.htm
- If a shared antenna is used it may either be connected “behind” the transceiver, in which case internal circuitry in the transceiver will protect the RSP, or using a splitter “in front of” the transceiver. If a splitter is used it is essential that a switch is implemented that isolates the RSP from the antenna during transmit!
- **In any configuration the maximum input power to the RSP must not exceed 0dBm**

On the following slides we will look at these configurations in more detail...

DO NOT directly connect the RSP to the same antenna as your transmitter, or to an antenna in the near field of a transmitting antenna, as this is likely to result in irreversible damage to your RSP and invalidate your warranty.

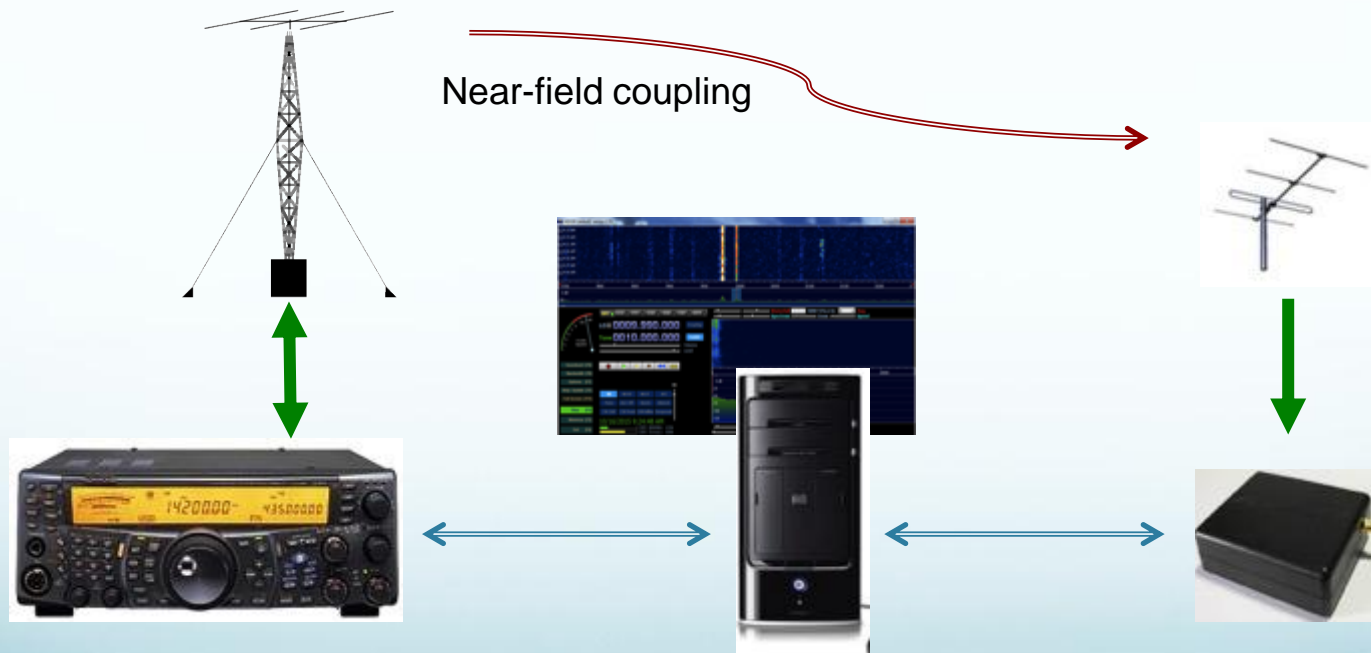
Panadapters

- Antenna Considerations



Separate antenna

- Care must be taken with the physical layout to ensure that near-field effects do not overload the RSP when you are transmitting from the transceiver.
 - See this article for a discussion of near-field effects: http://www.w8ji.com/antenna_coupling.htm



DO NOT directly connect the RSP to an antenna in the near field of a transmitting antenna, as this is likely to result in irreversible damage to your RSP and invalidate your warranty.

Panadapters

- Antenna Considerations



Shared antenna using splitter

- A switch must be used to isolate the RSP during transmit!



DO NOT directly connect the RSP to the same antenna as your transmitter as this is likely to result in irreversible damage to your RSP and invalidate your warranty.

Panadapters

- Antenna Considerations



Shared antenna “behind” the transceiver

- Internal circuitry isolates the RSP



- IF Out:
- Displayed bandwidth limited by transceiver on-board filters
 - RSP tuned to IF frequency
- RF Out:
- RSP can display up to the full 10MHz bandwidth capability

Panadapter -Software Requirements



- Any of the SDR Software programs that support the RSP can be used to provide a basic spectrum display.
- SDRUno, HDSDR, SDR-Console and CubicSDR all have built-in capabilities for rig control.
- OmniRig is recommended for ease of use when controlling a rig via CAT.
- Software manufacturer links:

SDRplay:	www.sdrplay.com
HDSDR:	www.hdsdr.de
SDR-Console:	www.sdr-radio.com
CubicSDR:	cubicsdr.com
OmniRig:	www.dxatlas.com/omnirig/

Note: Most popular SDR software packages can be downloaded from sdrplay.com. These packages come with an installer which includes all necessary API, Driver and/or EXTIO files for one step installation.

Where to buy:

- Ham Radio Outlet: www.hamradio.com
- Visit us at:

Oakland, CA

2210 Livingston St.
Oakland, CA
94606

Store Hours:

10AM-5:30PM Mon - Sat
Closed Sundays

Telephone hours:

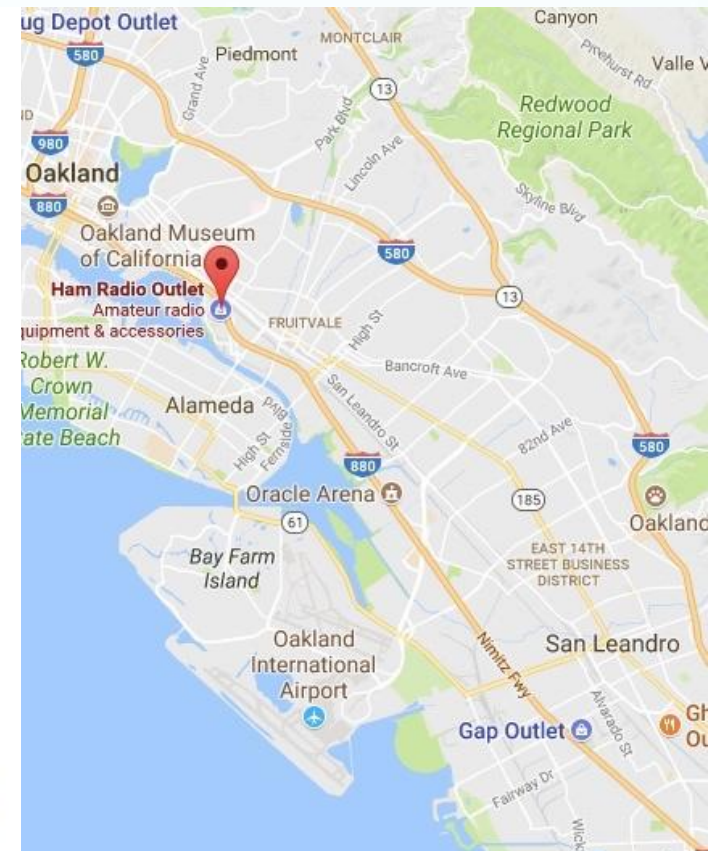
9:30AM-5:30PM Mon - Sat

Toll Free: 877-892-1745

Local: 510-534-5757

Fax: 510-534-0729

Email: oakland@hamradio.com



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For more information



- Company website: www.sdrplay.com
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- Community Forums: www.sdrplay.com/community/
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- Facebook: [SDRplay](#) and [SDRuno](#) specifically
 - Independent groups run by enthusiastic users!
- Google / YouTube
 - Many videos covering how to use the various software packages, implementing panadapters and much more. Use the Google search function!
 - SDRplay channel: https://www.youtube.com/channel/UC4JDq3US2eb1N4dRCT45_Zw